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ABSTRACT

The merits of networking and minicomputers in computer-assisted instruction (CAI) are reviewed. Cost figures for computer innovations and predictions about CAI are developed which include the forecast that costs will drop, minicomputers will dominate the market, and that the BASIC computer language will be the most widely used. (SK)

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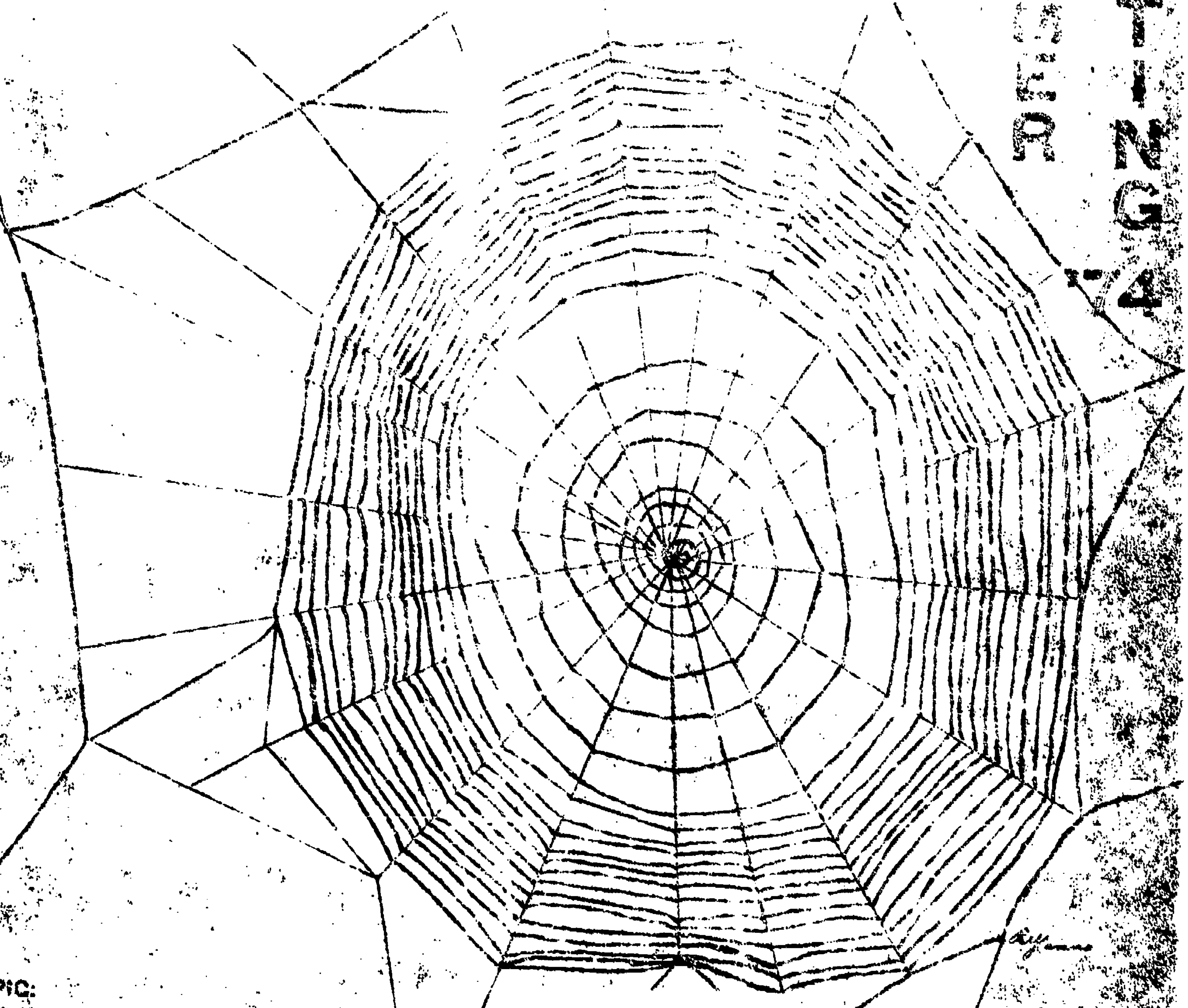

TOPIC:
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TITLE: THE COMPUTER AND ITS SOFTWARE

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The last decade has largely been one of development for computer assisted instruction. The next several years will be characterized by attempts to use what we have developed. These are exciting times characterized by contradiction. The two most interesting recent technical developments are the PLATO system and the rise of the ubiquitous minicomputer. The former has solved most of the problems of a truly sophisticated very large-scale system, the latter has proven that cost is no longer much of a consideration; computers are now free.

There are four components to a CAI system; the computer hardware itself, the terminals, software and courseware. I will not cover courseware in this discussion.

There are three hardware approaches currently. The first is the conventional COURSEWRITER, PILOT APL, etc. system frequently sharing machines of various sizes with background batch work and using teletype, IBM 2741 type terminals, or their glass equivalents. The second is the specialized hardware/software approach (IBM 1500, PLATO, etc.); and the third is the dedicated minicomputer/BASIC approach. The PLATO system should be commercially available from CDC by the summer's end, probably on a leased port basis, since few colleges and universities can afford a complete PLATO system. Several companies now market reliable multi-user BASIC minicomputer systems, for 16 terminals or more at $1500-$2000 per port without user mass storage and for between $2000 and $3000 with mass storage. The general decline in the cost of computing has also made the traditional approaches more feasible and their use has certainly increased.

FIGURE 1. HARDWARE APPROACHES

Computer	Language	Cost/Port	# of Terminals
small	BASIC	$2-3K	4-32
various	CW3, APL, PL/1	$3-10K	4-200
big	PLATO	$3-4K	500-2000

Not only the cost but also the nature of computing in general has changed in the last ten years, and CAI has and will continue to feel the affects of this change. Ten years ago we headed into the era where one machine was all things to all people. We are now backing away from that utopian approach. Batch work and interactive work, in fact, don't mix too well in a background/foreground system. Computers are cheap now and we don't have to do that sort of thing anymore to save money.

At the same time networking and resource sharing has become technologically feasible. Now users don't have to rush out and buy a machine, they can rent a piece of somebody else's action to get started, or they can even procure different specialized services they need from several different sources. It is ironic that the original reason for networking in education, to save hardware costs, has now disappeared just as networking has become technologically feasible.

Ten years ago some people predicted that with computers gaining in size and speed every year, we would soon replace all the computers in the U.S. with a dozen or so supercomputers placed strategically about the country providing computer power much like an electric utility. Today we not only have 100 of those same super computers but also several hundred thousand lesser machines scattered about the country.

Let us look for a moment at what networking can and cannot do. It does not save money on equipment. For most types of computing there are no economies of scale. A 360/50 for example does twice as much work as a 360/40, requires twice as many operators, and costs twice as much. Twice as much input/output requires twice as many input/output devices and twice as many keypunch, key disc, or key tape machines. The slight concessions most manufacturers give on large purchases are quickly offset by communications costs and the additional cost of remote terminals versus hardwired printers and card readers. At large scale centers of consolidated systems, reliability becomes the primary consideration. Reliability costs money: only standard software systems are permissible, redundancy of equipment is necessary, more hardware is necessary to handle the more complex software used to insure software reliability etc. The users must be kept happy at all costs. Innovation is difficult under these circumstances. In a small center economy takes precedence over reliability. When the system fails it is only a minor catastrophe and special arrangements can be made to handle special user problems created.

Networking does not lead to a reduction in total personnel: generally the reverse is true. When a computer is replaced by an RJE terminal to another computer, the original computer operators are replaced by RJE terminal operators. The number of programmer/analysts at remote sites generally remains the same even when an attempt is made at consolidating programming, since maintenance and documentation becomes more difficult. Local systems programmers are replaced by local HASP experts or their equivalents. Consolidation does lead to increased personnel needs at the main center.

Networking for consolidation does not necessarily lead to an increase in service; in fact often the reverse is true. The large center must of necessity be less accommodating and less flexible than the small. Response to technological change and innovation is generally slower in large centers than small (though being small does not guarantee anything, of course).

Networking as a supplement to existing load facilities can make specialized services accessible which are not economical to support locally. It would not be economical for a small college to maintain a bibliography of all books in print, for example, for a half dozen or so bibliographic searches per week. It would be cheaper for the small college to dial-up an available commercial service such as ERIC for this. An occasional large astronomy calculation can probably be better done on a large computer than on a small local machine. In other words; sharing yes, consolidation no.

Given the rate of change of prices today, the rate of new product development, the increasing complexity of off-the-shelf electronics components, I feel it is just as difficult now to make predictions as we now know it was ten years ago. Nevertheless suppose we try. I will concentrate on minicomputer based systems since it looks as though these will carry the bulk of interactive computing during the next few years in spite of the aesthetic appeal of PLATO and similar systems.

FIGURE 2. PRESENT MINICOMPUTER COSTS

PARTS	
Processor and box	$1500
Memory board 8K bytes	$1600
16K bytes	$2100
32K bytes	$3200
Low speed interface	$200-500
High speed interface	$3000-7000
Floating point instructions	$1000-3000
COMPLETE 64K BYTE COMPUTER	$8000-20,000

FIGURE 4. MASS (DISK) STORAGE

SINGLE PLATTER	10 PLATTER	3 PLATTER
(2315 Cartidge)	(2314 type)	CDC, CALCOMP
2-6 M bytes	30-60 M bytes	25-80 M bytes
150-300K/sec	300K/sec	800-1200K/sec
$3K	$7-10	$4-7

FIGURE 5. COST OF TERMINALS

TYPE	COST
TTY	$700-1500
Glass TTY	$700-2000
Super Terminals	$2000-6000
PLATO	$8000

FIGURE 6. USEFUL CAI TERMINAL FEATURES

24 lines by 80 characters long
upper/lower case characters
cursor control: ↑ ↓ → ← home
insert/delete character, line
speeds: 30, 120 characters/second
page mode
interfaces: RS232, TTY
interfaces to printers, casettes, slide projectors

The first prediction is that the price of computers will continue to drop. All core memory now operates at about one microsecond cycle time and costs a little less than 10¢ per byte for minicomputers. Semiconductor memory for large scale computers is about twice as fast but is less reliable and more expensive: it is not as cost effective yet. It is expected that core will fall in price by another factor of two during the next couple of years and will then probably level off. Semiconductor memory is also falling in price and will continue to fall after the price of core has leveled off. We can probably look for semiconductor memory to cost about 2 or 3 cents per byte five years from now. The price of memory actually determines the price of the entire computer, since reduced to its essentials, a computer consists of a processor and its memory, and processors are practically free. In a 64K byte minicomputer for example, the memory is 80% of the cost, the box and power supply is 10% and the processor is another 10%. More elaborate processors cost more; but the cost differences are for the most part artifically maintained by marketing decisions, rather than due to real production or design costs, and will respond to normal market pressures as the price of memory falls. At the moment a 15 inch by 15 inch board of electronics costs about $1000 and the price will fall to $500 in a year or so. Simple processors need less than one board, more elaborate ones two boards or possibly three. The entire 360 architecture can be duplicated on three boards, for example. The addition of selector channels, special purpose interfaces for disc drives, printers, card readers, etc., to the processor, can bring the price up to equal that of the memory, but not much more.

The second prediction is that most new computer systems will be minicomputers or collections of minicomputers. This is not as radical as it sounds. The minis are getting more complex and the distinction between minis and large scale computers is becoming more blurred. By the end of this year one company will introduce a 370/158-like machine whose processor will cost about $30,000. Large scale computers are generally run in a mode where the memory is chopped up with small work partitions of about 100K each and a complicated operating system is used to share the processor between the several work partitions. A simple comparison of the cost of the core for the complicated operating system to the cost of providing additional processor spells the doom of many of our large scale computers. Virtual memory can be used to handle occasional large jobs on small machines. DEC has proven that on the PDP-11.

The third prediction is that it will be possible to interface any brand or type of peripheral device desired to any brand of computer wanted. Digital technology has become so commonplace that there are people who can custom design interfaces for a reasonable price (often for less than the computer manufacturer) in almost every major city.

Peripheral devices, disc drives, interactive terminals, etc. are also undergoing a manufacturing upheaval. The price of disc drives has fallen from \$20000 for a 29 megabyte disc drive five years ago (67¢ per 1000 characters) to about \$8000 for 80 megabytes now (10¢ per 1000 characters) with a corresponding increase in operating sp ‹ and reliability. We can expect a similar change during the next few years accompanying a move towards non-mechanical mass storage devices in place of disc drives. The price of terminals has fallen also from \$5000 for a CRT a few years ago to \$1000 now and to \$500 in a year or so. A CRT, after all, is just a 100-dollar television set coupled to a 75-dollar keyboard by means of a 200-dollar controller, sold by a \$100-per-unit salesman.

More specialized terminals will be available and more optional features will be available on standard terminals. One method of operation that seems interesting for CAI is the possibility of driving a moderatel/ intelligent terminal by means of a CAI course on a casette tape that has previously been authored on a more complicated terminal.

Methods of operation brings us to software for terminal systems. Software can be divided into operating systems and language processors. The simplest system is one terminal connected to one minicomputer (a smart terminal). The development of microprocessors has opened a new field in this area as yet relatively unexplored. The next most complex system is many users each with their own memory but sharing a processor and peripherals. The most complex system is that of several users sharing one processor and memory by means of a swapping disc. The relative economics of the latter two systems depends on the number of users, the need for user file storage, etc.

There are several language approaches to CAI. One is to write everything in a generalized application language such as BASIC, FORTRAN, PL/1, or APL. One advantage is that it is gneerally easy for either author or student to exit from and re-enter the CAI course to perform numerical calucations. Here speed and program size is the probelm since the simpler languages run quickly per statement but require long programs for a CAI

course, while a course written in APL is a shorter program but consumptive of computer resources. I would include efforts at coding CAI statement handlers in BASIC in this category since in effect the whole course is executed in BASIC under such schemes. The second approach is to use a specialized CAI language such as COURSEWRITER, or the similar HP and DEC proprietary systems. The problem has been in the past that such languages pre-suppose one mode of course operation and generally have limited ability for handling numerical calculations. Generally courses written in such languages require assembly language patches to be successful. A third approach is to marry a specialized CAI language with an application language in assembler. This third approach is the one taken here at Western and seems to be a useful compromise. The CAI language processor generally runs quite quickly and the use of a traditional higher level language for numerical calculations allows the use of canned sub-routines. The fourth approach is the no-holds barred approach such as the PLATO system. Since I think the bulk of interactive computing in general and CAI in particular will be done on minicomputers during the next few years, I feel that the bulk of CAI will be done using the third approach; marrying a specialized CAI statement processor to a general purpose application language. Since BASIC appears to be the most common interactive language and since its use is growing faster than that of any other languages, I feel that the most successful CAI systems will use BASIC for numerical calculations.

Western is currently changing its orientation towards interactive computing on minicomputers. The CAI system currently running on our 360/40 is of the married language type and we are very pleased with it, except for the limitations imposed on the number of terminals by the power of our 360. We are moving to minicomputers because we can't afford to increase the number of terminal hours per week any other way.